will be found. The chief productions are indigo, lacquer, saffron, rice, cotton, &c., but the industry of the country is in a very undeveloped state.

A NEW project for the creation of an inland sea has been advanced and advocated by General Fremont, at present Governor of Arizona. The removal of a barrier ridge, he affirms, would admit the waters of the Gulf of California into an ancient basin, and would create a navigable inland sea 200 miles long, 50 miles broad, and 300 feet deep. This piece of engineering, which is very like Roudaire's Algerian inland sea project, he claims, would convert what is now a desert region into a commercial highway, and would greatly improve the climate of Southern Arizona and California.

AT last week's meeting of the Paris Academy M. de Lesseps announced that in a letter of April 15, Capt. Roudaire states that the sounding operations were being pursued with vigour and success, and that so far they justified the expectation of being able to create an interior Algerian Sea.

AN exploring expedition to New Guinea is being organised at Wellington, New Zealand, on a large scale.

L'Exploration states that a new African expedition is being organised at Lisbon, under the direction of Capt. Paiva d'Andrada. Its object is the exploration of the Zambezi and the foundation of commercial and agricultural colonies in the territories of Fete and Zoumbo.

IN the *Verhandlungen* of the Berlin Geographical Society, Nos. 2 and 3, is a suggestive paper by Dr. Güssfeldt on the Ice-Conditions of High Mountains. No. 80 of the *Zeitschrift* contains a paper of much originality, on the causes which have conduced to the formation of the surface of Norway, by Prof. Kjerulf.

Globus is publishing a valuable series of articles on the Red River of the North, from the French of M. de Lamothe, and the Hundu Kush Alps by Herr Emil Schlagentweit.

NOTES

THE Annual London Meeting of the Iron and Steel Institute will be held on Wednesday, Thursday, and Friday, May 7, 8, and 9, at the Institution of Civil Engineers, 25, Great George Street, Westminster. The following programme of proceedings has been arranged :—On Wednesday the retiring President (Dr. C. W. Siemens, F.R.S.), will take the chair at 10.30 A.M., and the President-Elect (Mr. Edward Williams) will deliver his inaugural address. The Bessemer Medal for 1879 will be presented to Mr. Peter Cooper, of New York, "the father of the American iron trade." The adjourned discussion on the paper read at Paris by Mr. Daniel Adamson, C.E., of Manchester, on "The Mechanical Properties of Iron and Mild Steel," will be resumed, and Mr. Adamson will present a supplementary paper. On the following days the following papers will be read and discussed :—"On the Use of Steel in Naval Construction," by Mr. Nathaniel Barnaby, C.B., H.M.'s Chief Constructor. "On the Use of Steel in the Construction of Bridges," by Mr. H. N. Maynard. "On the Elimination of Phosphorus in the Bessemer Converter," by Mr. Sydney G. Thomas, F.C.S., and Mr. Percy C. Gilchrist, A.R.S.M., F.C.S. "On the Removal of Phosphorus and Sulphur during the Bessemer and Siemens-Martin Processes of Steel Manufacture," by Mr. G. J. Snelus, F.C.S., &c. "On a New Volumetric Method of Determining Manganese in Manganiferous Iron Ores, Spiegeleisen, Steel, &c.," by Mr. John Pattinson, F.I.C., Newcastle-on-Tyne. "On a Ready Means of Moulding Lime, and making Lime or Basic Bricks and Linings for Furnace Converters, &c.," by Mr. Edward Riley, F.C.S., F.I.C., &c. "On a Practical Combination of the Bessemer and Puddling Processes," by Mr. Edwin Pettitt, Cheltenham. "On the Results of Working the Godfrey-Howson Furnaces at the Works of Tamaris, Gard, France," by M. Escalle. "On the Chemistry of Puddling," by Mr. H. Louis, A.R.S.M., Londonderry, Nova Scotia. "On a New Process for Protecting Iron and Steel against Rust," by Prof. Barff.

THE Rev. W. H. Dallinger, F.R.S., has been appointed Rede Lecturer at Cambridge this year.

AMONG those on whom the degree of LL.D. has been conferred by the Glasgow University is Dr. C. W. Siemens, Prof. Hull, director of the Irish Geological Survey, and Prof. Dickson, newly elected to the Edinburgh Chair of Botany.

THE death is announced of Dr. Charles Murchison, F.R.S.

MADEMOISELLE ADELAÏDE MONTGOLFIER, a daughter of the inventor of balloons, is still alive, aged eighty-nine years. She is possessed of a large fortune, and presented the Museum of the Aëronautical Academy with a copy of the large medal executed by Houdon, and representing her father and uncle, who was associated with him in the invention of balloons. This medal was executed to commemorate that event. A movement will be got up in France for celebrating the centenary of that memorable event, which took place in June, 1783, in the vicinity of Lyons.

THE annual conference on National Water Supply, Sewage, and Health, will be held in the rooms of the Society of Arts, on Thursday and Friday, May 15 and 16, 1879. There will be an Exhibition of Mechanical and Chemical Apparatus in connection with Water Supply, Treatment of Sewage, and Health. Papers on any of above heads are requested. The object of the conference is to discuss existing information in connection with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the conference will be printed and circulated at the meetings.

PROF. TYNDALL has been instructing the Select Committee appointed to inquire into the subject of electric lighting. He gave a brief sketch of the history of electricity and of its application to lighting purposes, illustrating his evidence by several interesting experiments. Seeing what had been done by Mr. Edison, he believed that many of the existing difficulties would be removed; for public illumination he was afraid platinum would be too expensive. Dr. Siemens has also been giving important evidence on the subject.

WE are glad to see that Dr. Brehm, the well-known naturalist, accompanies the Crown Prince of Austria in his tour through Spain.

WE learn from *Science News* that the Brazilian Government has appointed Mr. Orville A. Derby as geologist to the National Museum at Rio de Janeiro, to succeed the late Prof. Hartt, whose assistant Mr. Derby had been for a number of years. Next to Prof. Hartt, Mr. Derby was probably best acquainted with the geological structure of Brazil, and he is, therefore, the one most fitted to carry on the work. He accompanied Prof. Hartt, as an assistant, on both of his Amazonian trips, in 1870 and 1871, and largely shared in the honours arising from the discoveries made during those years, by which a firm foundation was laid for the complete geological exploration of the great valley.

THE following arrangements have been made for the meetings of the Society of Arts after Easter :—At the ordinary meetings on Wednesday evenings, at eight o'clock: May 14—"The Automatic Hydraulic Brake," by E. D. Barker; May 21—"Edison's New Telephone," by Conrad W. Cooke. In the African Section, on Tuesday evenings at eight o'clock: May 27—"The Contact of Civilisation and Barbarism in Africa, Past and Present," by Edward Hutchinson. In the Chemical Section, on Thursday evenings, at eight o'clock: May 8 and 15—"The History of Alizarine and Allied Colouring Matters, and their Production from Coal Tar," by W. H. Perkin, F.R.S. In the Indian Section, on Friday evenings, at eight o'clock: May 2—"The Wild Silks of India, especially Tussah," by Thomas Wardle; May 23—"The Harbour of Kurrachee," by W. J. Price.

A SPECIMEN of the electro-magnetic engine invented by M. Marcel Deprez is employed by the Academy of Aëronautical Ascensions, 50, rue Rodier, Paris, for working a sewing-machine which is used for the construction of a balloon called *L'Électricité*. The weight of the motor is only 4 kilogrammes, and four Bunsen elements of ordinary size are sufficient to give to the needle the required velocity.

FROM to-day postal cards will be sold in Paris at the price of 50 centimes each, for the transmission of messages by the pneumatic tube which connects the several telegraphic stations in the French metropolis.

IN a memoir presented to the Academy of Sciences and Literature of Lyons, we learn from the *British Medical Journal*, Dr. Henry H. Dor, a well-known oculist, contests the view held by Mr. Gladstone, and by Geiger and Magnus of Boston, that our ancestors were colour-blind, a view deduced from their writings and from the different names which they have given to colours. Dr. Dor endeavours to demonstrate that now, as in the time of Homer, poets insist too little upon the indications of the colours, but much more upon their luminous intensity. Moreover, Dr. Dor says that persons who do not possess any knowledge of physics find much difficulty in distinguishing the colours of the rainbow, and only see in it three or four colours, in place of the seven classical colours of its composition. Further, it results even from the very study of the Assyrian and Egyptian monuments, that those nations had not only perceived, but imitated, the greater part of the colours of which we are at present cognisant.

THE second annual meeting of the Midland Union of Natural History Societies will be held in the council chamber of the Town Hall, Leicester, on Tuesday, May 20, at half-past three o'clock. The business of the meeting will be to receive the report of the Council and the treasurer's accounts; to fix the place of the next annual meeting in 1880; to consider any suggestions that members may offer; to discuss the work of the Union during the coming year; and to transact all necessary business. The President will open the business with an address. A *conversazione* will be held in the Leicester Town Museum (entrance in Hastings Street) on Tuesday evening, May 20, the arrangements for which are under the direction of the Leicester Literary and Philosophical Society. There will be an exhibition of objects of general scientific interest, microscopy, the various departments of natural history, archæology, and art. On Wednesday, May 21, there will be an excursion to Charnwood Forest.

FROM the *Gardeners' Chronicle* we learn that an Agricultural and Horticultural Society has been founded at Mentone, many of the members being English residents.

THE *Electrician* of April 26 contains a long letter from Prof. Clerk Maxwell on the correct definition of "Potential."

AMONG Mr. Murray's list of announcements is "The River of Golden Sands," a narrative of a journey through China to Burmah, by Capt. William Gill, R.E., and "A History of Ancient Geography," by E. H. Bunbury.

THE *American Naturalist* for April contains a curious paper, by Mr. Xenos Clarke, on "Animal Music, its Nature and Origin." Mr. W. O. Crosby has a paper on "Native Bitumens and the Pitch Lake of Trinidad," and Mr. W. H. Holmes on a Deposit of Obsidian in the Yellowstone Park.

GRAVITATION experiments in liquids have recently been made by Herr Schröttner in Vienna, with a view to determining viscosity (as previously proposed by Pisati and De Heen). He took as basis a formula of Stokes for the resistance of a ball moved in a straight line in a liquid, and sought to determine the coefficients of friction in absolute measure. The practicability of the method was proved in a very viscous mixture of black pitch and beech-tar, and in concentrated glycerine. For the latter, higher values were obtained than by the transpiration-experiments carried on at the same time. From the author's experiments with glycerine, as also from Schieck's gravitation experiments with water, it appeared that the coefficients of friction were considerably greater whenever the velocities of fall exceeded a certain amount. For liquids with little viscosity, as water, small velocities of fall, such as met the conditions of experiment, could only be obtained by giving the balls a surplus weight of a few hundredths of a milligramme over the displaced mass of liquid, in case experiments were not made with very large balls and very considerable quantities of liquid.

ROMAN remains have just been discovered at Oberbreisig, a village near the Rhine, a few miles to the south of Bonn. A rectangular building of unquestionably Roman origin has been laid bare, the purpose of which, however, is very doubtful. The excavations leading to this discovery are in connection with others of greater extent which are being made in the neighbourhood, and which are principally directed to the investigation of a Roman villa near Waldorf and a Roman road leading to Sinzig.

IN a recent memoir communicated to the Belgian Academy, M. Lagrange offers some novel views on the formation of bodies in the universe. He supposes that before any expenditure of work the quantity of heat of the universe was *nil*, and that the temperature was gradually raised above absolute zero at the expense of work done by attraction. Hence the formation of solid bodies must have preceded that of liquids and gases. Through the gradual condensation of matter and consequent enormous development of heat, the earth would attain, at least in the parts near the surface, the state of fluidity necessary to explanation of its form and geological characters. As the temperature gradually rose with gradual agglomeration of matter, a very dense atmosphere would form, with pressure diminishing outwards, and in a more advanced phase, the temperature of this, after reaching a maximum, would gradually diminish, causing liquefaction or solidification of certain matters at first vaporous, while other solid bodies might remain suspended in the atmosphere. M. van der Mensbrugghe commends the author's views as original and worthy of the attention of *savants*, but, with M. Folie, he regards the initial absolute zero as inadmissible. In reply to objections by M. Folie, the author promises shortly to defend this hypothesis:—Space is occupied by two substances; one, attractive, which is matter properly so-called, or material atoms; the other, repulsive, which occupies the inter-atomic space, and from which results, between any two atoms, a variable repulsion exercised at the surface of the latter.

WE have received No. 11 (March, 1879) of the *Bulletin* of the Brooklyn Entomological Society, of the existence of which publication we were not previously aware. It consists of a half-sheet 8vo, with one plate, illustrating a paper by C. F. Gissler on Coleopterous larvæ of the family *Tenebrionidæ*, which appears to be carefully worked out and likely to prove of value, and the figures (chiefly concerning the pygidia and antennæ) seem to be well drawn. The other papers are on the genus *Colias*, *Samia cynthia*, and on some species of *Thecla*. The number of

American serials exclusively devoted to entomology is constantly increasing.

A SLIGHT earthquake was felt between 9.15 and 9.30 P.M., April 24, at Sigmaringen. The direction was not observed. The following particulars have reached the *Times* of the earthquake which occurred in Persia on March 22, at 3.42 A.M. (London time, 12.37 A.M.). It lasted 12s., was felt at Tauris and east as far as Zendjan; no damage was caused in Tauris, but in the vicinity of Mianeh, where the shocks continued with more or less vigour up to April 2, great damage and loss of life have occurred. An official report, prepared for the Persian Government by the Persian Telegraph authorities at Mianeh gives the damage, as far as is at present known, as follows:—21 villages totally destroyed, 54 greatly damaged, 922 persons killed, together with 2,660 sheep, 1,125 oxen, 124 horses, and 55 camels. The centre of the disturbances was the mountain of Bousgouche.

WE learn from the *Colonies and India* that an American explorer has recently discovered in the little-known district of Yucatan, bordering on British Honduras, a valuable insect, possessing properties which ought to make it a rival of the cochineal and shellac-producing insects. This is the *neen*, or *niin*, a species of *Coccus*, which feeds on the mango tree and similar plants, and exists in enormous quantities in Central America. It is of considerable size, of a yellowish brown colour, and emits a peculiar oily odour, containing as it does, a large quantity of fatty oil, or rather grease. This grease is used by the natives for various purposes, being highly prized as a medicinal oil for external application, and it is also employed for mixing paints. It can be made to change its condition very considerably by different processes. When exposed to great heat, the lighter oils evaporate, leaving a tough flexible mass, resembling half-softened wax, but unaffected by heat or cold, which may be used as a lacquer or varnish. When burnt, this material produces a thick semi-fluid mass, somewhat resembling a solution of india-rubber, which after a few days becomes hard and solid. As a cement this substance will be invaluable, and it might also be used for waterproofing purposes.

WITHIN a few days the scientific committee for the organisation of the Paris Exhibition of Applied Sciences will hold an important meeting. The exhibition will be open from July to November.

SEVERAL of the Conseils Généraux of the surrounding departments have voted funds for the erection of an observatory on the top of Mont Ventoux, in Vaucluse. It will be the third high meteorological station in France, and very likely not the last. M. Ferry, the Minister of Public Instruction, is favourable to the erection.

"THE Silk-Worm, being a brief Manual of Instruction for the Production of Silk," is the title of a pamphlet by Mr. C. V. Riley, professor of the U.S. Department of Agriculture. Silk-worm rearing seems likely to become an important industry in some parts of the United States.

THE March number of the *Journal* of the Statistical Society contains the concluding part, upwards of 180 pages, of Mr. C. Walford's elaborate and valuable paper on the Famines of the World. The whole paper, we believe, will be published separately.

MESSRS. HEYWOOD, of Manchester, have just published the tenth series of Science Lectures for the People delivered in that city. The volume, which can be had for a few pence, contains nine lectures by some of the most eminent men of science of the day. Huxley lectures on William Harvey, Roscoe on the Sun, Flower on the Tasmanians, Williamson on Insectivorous Plants, Barrett on Edison and his Inventions, Dawkins on Our Earliest Ancestors in Britain, Abel on the Modern History of Gunpowder, Dallinger on the Minutest Forms of Life, and Romanes on Animal Intelligence. Several of the lectures are illustrated.

MR. RICHARD RATHBUN has reprinted from the *Proceedings* of the Boston Society of Natural History, a pamphlet of 25 pages on the Devonian brachiopoda of the Province of Para, Brazil. The list is a long one, and many species are described for the first time.

IT will be difficult to surpass or even equal our American friends in the illustrated scientific works which they have begun to publish in such quantity. We have had occasion to mention more than one work of this class recently, and now we receive the first part of "Characeæ Americanæ," illustrated, described and published by Dr. T. F. Allen, of New York. The particular specimen described, and illustrated by an exquisitely coloured plate, is *Chara gymnopus*, A. Br., var. *elegans*, A. Br.

WE have on our table the following works:—"Our New Protectorate," 2 vols., J. C. McCoan (Chapman and Hall); Karl von Gebler's "Galileo Galilei," translated by M. Sturge (Kegan Paul and Co.); "The Encyclopædia Britannica," vol. ix. (A. and C. Black); "Geography" (School Books for South Africa, No. 1), Dr. John Shaw (W. Collins); "Elements of Natural Philosophy," Part i., Second Edition, Thomson and Tait (Printed at Cambridge University Press); "Chemistry of Common Life," J. F. W. Johnson and A. H. Church (Blackwood and Co.); "Shadows of the Coming Truth" (Elliot Stock); "Caves of South Devon and their Teachings," J. E. Howard (Hardwicke and Bogue); "Scientific Results of the Second Yarkand Mission;" 6 Plates, from the Notes of Ferdinand Stoliczka (Quaritch); "End-on Illumination in Private Spectroscopy," Piazzi Smyth (Neil and Son, Edinburgh); C. Peschel's "Geschichte der Erdkunde," Parts i. and ii., Edited by Prof. Dr. Sophus Ruge (R. Oldenburgh, München); "Pre-Historic Times," fourth edition, Sir John Lubbock, Bart. (F. Norgate); "Dictionary for Architects," No. 1, W. J. Christy (Griffith and Farren); "Reduction of Greenwich Meteorological Observations" (Spottiswoode); "The Flowers of the Sky," R. A. Proctor (Strahan); "On Certain Effects of Starvation on Vegetable and Animal Tissues" (D. D. Cunningham, Government Printer, Calcutta); "The Microscopic Organisms found in the Blood of Man and Animals" (Government Printer, Calcutta); "Rambles in North-Western America," J. M. Murphy (Chapman and Hall); "Atlas of Histology, Parts 1 and 2, E. Klein and N. Smith (Smith Hall); "How to learn Danish," E. C. Otté (Trübner and Co.); "Key to How to Learn Danish," E. C Otté (Trübner and Co.); "Anatomy and Physiology of Man," G. G. P. Bale (Remington and Co.); "On Artificial Manures," by M. Georges Ville, translated and edited by William Crookes (Longmans); "Agricultural Ants of Texas," H. C. McCook (Trübner); "De la Ligue Contre les Vivisections, ou la Nouvelle Croisade," Par un Anglais (Ernest Leroux); "L'Eclairage Electrique," Le Comte Th. du Moncel (Hachette); "Contributions to the Anatomy of the Central Nervous System of Vertebrate Animals," Alfred Saunders; "Infection—Diseases in the Army," Prof. R. Virchow (H. K. Lewis); "Recherches sur l'Électricité," Gaston Planté (Paris, A. Fournan); "On the Daily Inequality of the Barometer" (W. W. Rundell); "Freedom in Science and Teaching," Ernst Haeckel (Kegan Paul and Co.).

THE additions to the Zoological Society's Gardens during the past week include a Black-handed Spider Monkey (*Ateles melanochir*) from Central America, presented by Mr. D. R. Comyn; two Prairie Marmots (*Cynomys ludovicianus*) from North America, presented by Mr. W. G. Marshall; a Guilding's Amazon (*Chrysotis guildingi*) from St. Vincent, West Indies, presented by Mr. G. Dundas, C.M.Z.S.; a Cuvier's Podargus (*Podargus cuvieri*) from Australia, presented by Mr. R. S. C. Baber; a Lesser Long-eared Bat (*Plecotus brevimanus*), British Isles, presented by Mr. J. Ward; a three-toed Amphiuma (*Amphiuma means*) from North America, presented by Mr. A. C. Cole; a Bonnet Monkey (*Macacus radiatus*) from India, an Egyptian Cat (*Felis chaus*) from North Africa, a Common Ass (*Asinus vulgaris*) from Persia, a Grey-headed Porphyris (*Porphyris poliocephalus*) from South Asia, a Puff Adder (*Vipera arietans*) from the Cape of Good Hope, deposited.

RECENT CONTRIBUTIONS TO THE HISTORY OF DETONATING AGENTS[1]

AMONG the many explosive preparations which have during the last thirty years been proposed as substitutes for gunpowder, on account of greater violence and other special merits claimed for them, not one has yet competed with it successfully as a propelling agent, nor even as a safe and sufficiently reliable explosive agent for use in shells; for industrial applications and for very important military or naval uses, dependent upon the destructive effects of explosives, it has had, however, to give place, to a very important extent, and in some instances altogether, to preparations of gun-cotton and nitro-glycerine.

But there appeared little prospect that either gun-cotton or nitro-glycerine, whether used in their most simple condition or in the forms of various preparations, would assume positions of practical importance as explosive agents of reliable, and therefore uniformly efficient, character, until the system of developing their explosive force through the agency of a detonation, instead of through the simple agency of heat, was elaborated.

Before the first step in this important advance in the application of explosive agents was made by Alfred Nobel, about twelve years ago, the very variable behaviour of such substances as gun-cotton and nitro-glycerine, when exposed to the heat necessary for their ignition under comparatively slight modifications of attendant conditions (*e.g.* as regards the completeness and strength of confinement or the position of the source of heat with reference to the main mass of the material to be exploded) rendered them uncertain in their action, and at any rate, only applicable under circumstances which confined their usefulness within narrow limits. The employment by Nobel of an initiative detonation, produced by the ignition of small quantities of mercuric fulminate or other powerful detonating substances, strongly confined, for developing the violent explosion, or detonation, of nitro-glycerine, opened a new field for the study of explosive substances, and the first practical fruit was the successful application of plastic preparations of nitro-glycerine and of compact forms of compressed gun-cotton, with simplicity and certainty, to the production of destructive effects much more considerable than could be accomplished through the agency of much larger amounts of gunpowder, applied under the most favourable conditions. Whereas very strong confinement has been essential for the complete explosion of these substances, so long as the only known means of bringing about their explosion consisted simply of the application of fire or sufficient heat, no confinement whatever is needed for the development, with certainty, of a decidedly more violent explosive action than they are capable of exerting when thus applied, if they are detonated by submitting some portion of the mass to the blow or concussion developed by a sharp detonation, such as is produced by the ignition of a small quantity of strongly confined mercuric fulminate.

The conditions essential to the development of detonation in masses of nitro-glycerine and gun-cotton, or preparations of them, and the relations to and behaviour towards each other of these and other explosive bodies, in their character or functions as detonating agents, have been made the subject of study by the lecturer during the last ten years, and some of the earlier results published by him in connection with this subject also led to the pursuit of experimental inquiries of analogous character by Champion and Pellet and others.

Some of the chief results attained by Mr. Abel's experiments may be briefly summarized.

It was found that the susceptibility to detonation, as distinguished from explosion, through the agency of an initiative detonation, is not confined to gun-cotton, nitro-glycerine, and preparations containing those substances, but that it is shared, though in very different degrees, by all explosive compounds and mixtures.

It was demonstrated that the detonation of nitro-glycerine and other bodies, through the agency of an initiative detonation, is not ascribable simply to the direct operation of the heat developed by the chemical changes of the charge of detonating material, and that the remarkable property possessed by the sudden explosion of small quantities of certain bodies (the mercuric and silver fulminates) to accomplish the detonation of nitro-glycerine and gun-cotton, is accounted for satisfactorily by the mechanical force thus suddenly brought to bear upon some part of the mass operated upon. Most generally, therefore, the degree of facility with which the detonation of a substance will develop similar change in a neighbouring explosive substance, may be regarded as proportionate to the amount of force developed *within the shortest period of time* by that detonation, the latter being in fact analogous in its operation to that of a blow from a hammer or of the impact of a projectile.

Thus, explosive substances which are inferior to mercuric fulminate in the suddenness, and the consequent momentary violence of their detonation, cannot be relied upon to effect the detonation of gun-cotton, even when used in comparatively considerable quantities. Percussion cap composition, for example, which is a mixture of fulminate with potassium chlorate, and is therefore much less rapid in its action than the pure fulminate, must be used in comparatively large quantities to accomplish the detonation of gun-cotton.

The essential difference between an explosion and what we now distinguish as a detonation lies in the comparative suddenness of the transformation of the solid or liquid explosive substance into gas and vapour.

The gradual nature of the explosion of gunpowder is illustrated, in its extreme, by burning a train of powder in open air; the rapidity and consequent violence of the explosion is increased in proportion to the degree of confinement of the exploding charge, or to the resistance opposed to the escape or expansion of the gases generated upon the first ignition of the confined substance.

In the case of a very much more sensitive and rapidly explosive substance than gunpowder, such as mercuric fulminate, the increase in the rapidity of its transformation, by strong confinement, is so great that the explosion assumes the character of a detonation in regard to suddenness and consequent destructive effect. A still more sensitive and rapidly explosive material (such as the silver fulminate and iodide of nitrogen) produces when exploded in open air effects akin to those of detonation; yet even with these bodies, confinement operates in increasing the rapidity of the explosive to suddenness, and consequently in developing a more purely detonative action.

Detonation, developed in some portion of a mass, is transmitted with a velocity approaching instantaneousness throughout any quantity, and even if the material is laid out in the open air in long trains composed of small masses. The velocity with which detonation travels along trains thirty or forty feet in length, composed of distinct masses of gun-cotton and of dynamite, has been found to range from 17,000 to 24,000 feet per second. Even when trains of these explosive agents were laid out with intervening spaces of half an inch between the individual masses composing the trains, detonation was still transmitted along the separated masses with great though diminished velocity.

The suddenness with which detonation takes place has been applied as a very simple means of breaking up shells into small fragments and scattering these with considerable violence, with employment of very small charges of explosive agent. Thus by filling a 16-pr. common shell completely with water and inserting a charge of ½ oz. of gun-cotton fitted to a detonating fuze, the shell being thoroughly closed by means of a screw plug, the force developed by the detonation of the small charge of gun-

---

[1] Weekly Evening Lecture at the Royal Institution, Friday, March 21, 1879. By Professor Abel, C.B., F.R.S. Revised by the Author.